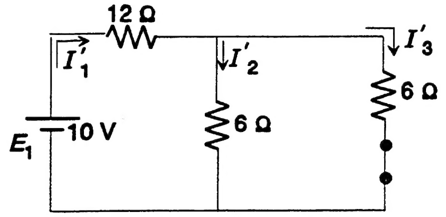
CHAPTER 9 (Odd)

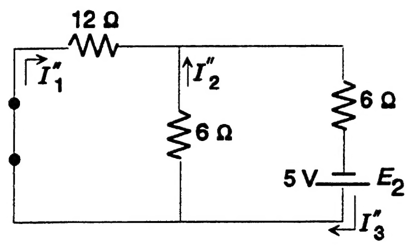
1. a. E_1:



$$I'_1 = \frac{10\text{ V}}{12\ \Omega + 6\ \Omega \| 6\ \Omega} = \frac{10\text{ V}}{12\ \Omega + 3\ \Omega} = \frac{2}{3}\text{ A}$$

$$I'_2 = I'_3 = \frac{I'_1}{2} = \frac{1}{3}\text{ A}$$

E_2:



$$I''_3 = \frac{5\text{ V}}{6\ \Omega + 6\ \Omega \| 12\ \Omega} = \frac{5\text{ V}}{6\ \Omega + 4\ \Omega} = \frac{1}{2}\text{ A}$$

$$I''_1 = \frac{6\ \Omega(I''_3)}{6\ \Omega + 12\ \Omega} = \frac{1}{6}\text{ A}$$

$$I''_2 = \frac{12\ \Omega(I''_3)}{12\ \Omega + 6\ \Omega} = \frac{1}{3}\text{ A}$$

$$I_1 = I'_1 + I''_1 = \frac{2}{3}\text{ A} + \frac{1}{6}\text{ A} = \mathbf{\frac{5}{6}\text{ A}}$$

$$I_2 = I'_2 - I''_2 = \frac{1}{3}\text{ A} - \frac{1}{3}\text{ A} = \mathbf{0\text{ A}}$$

$$I_3 = I'_3 + I''_3 = \frac{1}{3}\text{ A} + \frac{1}{2}\text{ A} = \mathbf{\frac{5}{6}\text{ A}}$$

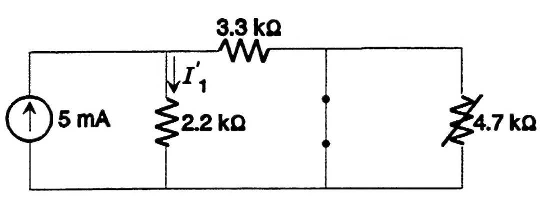
b. E_1: $P'_1 = I'^2_1 R_1 = \left(\frac{2}{3}\text{ A}\right)^2 12\ \Omega = \mathbf{5.333\text{ W}}$

E_2: $P''_1 = I''^2_1 R_1 = \left(\frac{1}{6}\text{ A}\right)^2 12\ \Omega = \mathbf{0.333\text{ W}}$

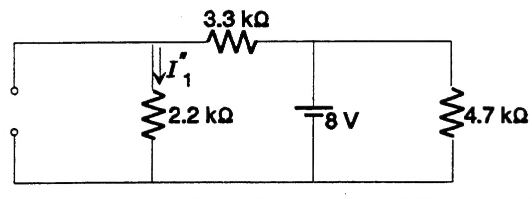
c. $P_1 = I_1^2 R_1 = \left(\frac{5}{6}\text{ A}\right)^2 12\ \Omega = \mathbf{8.333\text{ W}}$

d. $P'_1 + P''_1 = 5.333\text{ W} + 0.333\text{ W} = 5.666\text{ W} \neq 8.333\text{ W} = P_1$

3. a.



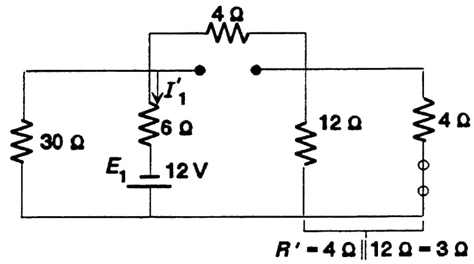
$$I_1 = \frac{3.3\text{ k}\Omega(5\text{ mA})}{2.2\text{ k}\Omega + 3.3\text{ k}\Omega} = \frac{16.5\text{ mA}}{5.5} = 3\text{ mA}$$

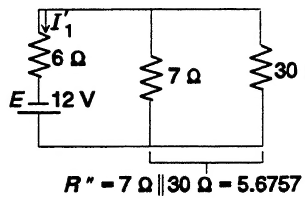


$$I''_1 = \frac{8\text{ V}}{3.3\text{ k}\Omega + 2.2\text{ k}\Omega} = \frac{8\text{ V}}{5.5\text{ k}\Omega} = 1.4545\text{ mA}$$

$$I_1 = I'_1 + I''_1 = 3\text{ mA} + 1.4545\text{ mA} = \mathbf{4.4545\text{ mA}}$$

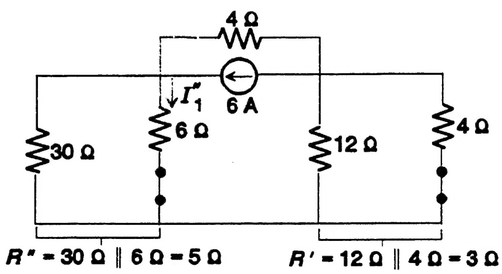
b. E_1:

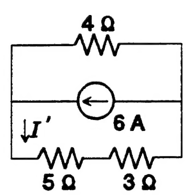




$$I'_1 = \frac{E_1}{R_T} = \frac{12\ \text{V}}{6\ \Omega + 5.6757\ \Omega} = 1.0278\ \text{A}$$

I:

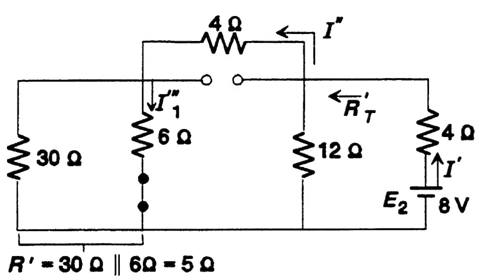




$$I' = \frac{4\ \Omega(6\ \text{A})}{4\ \Omega + 8\ \Omega} = 2\ \text{A}$$

$$I''_1 = \frac{30\ \Omega(2\ \text{A})}{30\ \Omega + 6\ \Omega} = 1.667\ \text{A}$$

E_2:



$$R'_T = 12\ \Omega \| (4\ \Omega + 5\ \Omega) = 12\ \Omega \| 9\ \Omega = 5.143\ \Omega$$

$$I' = \frac{E_2}{R_T} = \frac{8\ \text{V}}{4\ \Omega + 5.143\ \Omega} = 0.875\ \text{A}$$

$$I'' = \frac{12\ \Omega(I')}{12\ \Omega + 9\ \Omega} = \frac{12\ \Omega(0.875\ \text{A})}{21\ \Omega} = 0.5\ \text{A}$$

$$I'''_1 = \frac{30\ \Omega(I'')}{30\ \Omega + 6\ \Omega} = \frac{30\ \Omega(0.5\ \text{A})}{36\ \Omega} = 0.4167\ \text{A}$$

$$I_1 = I_{R_1} = I'_1 + I''_1 + I'''_1$$
$$= 1.0278\ \text{A} + 1.667\ \text{A} + 0.4167\ \text{A} = \mathbf{3.11\ A}$$

5. a. $R_{Th} = R_3 + R_1 \| R_2 = 4\ \Omega + 6\ \Omega \| 3\ \Omega = 4\ \Omega + 2\ \Omega = \mathbf{6\ \Omega}$

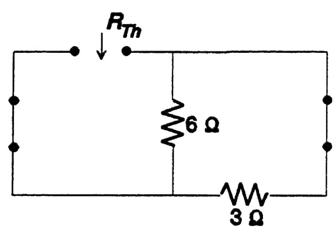
$$E_{Th} = \frac{R_2 E}{R_2 + R_1} = \frac{3\ \Omega(18\ \text{V})}{3\ \Omega + 6\ \Omega} = \mathbf{6\ V}$$

b. $I_1 = \dfrac{E_{Th}}{R_{Th} + R} = \dfrac{6\ \text{V}}{6\ \Omega + 2\ \Omega} = \mathbf{0.75\ A}$

$$I_2 = \frac{6\ \text{V}}{6\ \Omega + 30\ \Omega} = \mathbf{0.1667\ A}$$

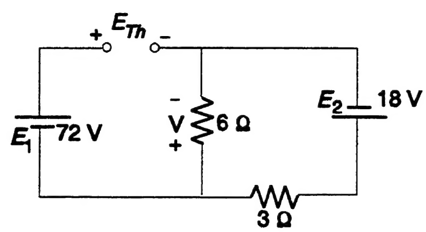
$$I_3 = \frac{6\ \text{V}}{6\ \Omega + 100\ \Omega} = \mathbf{0.0566\ A}$$

7. (I): R_{Th}:



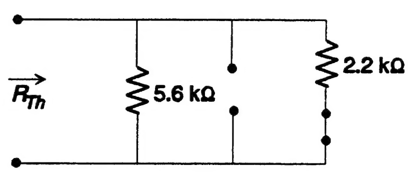
$R_{Th} = 6\ \Omega \parallel 3\ \Omega = \mathbf{2\ \Omega}$

E_{Th}:



$$V = \frac{6\ \Omega(18\ \text{V})}{6\ \Omega + 3\ \Omega} = 12\ \text{V}$$
$$E_{Th} = 72\ \text{V} + \text{V} = \mathbf{84\ V}$$

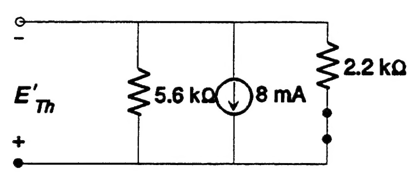
(II): R_{Th}:



$R_{Th} = 5.6\ \text{k}\Omega \parallel 2.2\ \text{k}\Omega = \mathbf{1.579\ k\Omega}$

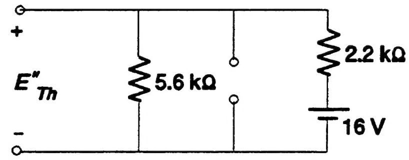
E_{Th}: Superposition:

I:



$$E'_{Th} = IR_T$$
$$= 8\ \text{mA}(5.6\ \text{k}\Omega \| 2.2\ \text{k}\Omega)$$
$$= 8\ \text{mA}(1.579\ \text{k}\Omega)$$
$$= 12.636\ \text{V}$$

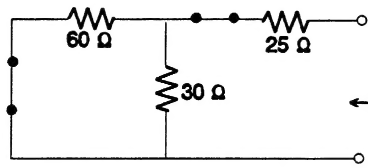
E:



$$E''_{Th} = \frac{5.6\ \text{k}\Omega(16\ \text{V})}{5.6\ \text{k}\Omega + 2.2\ \text{k}\Omega} = 11.487\ \text{V}$$

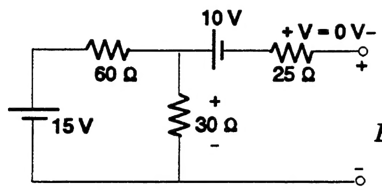
$$\overset{+}{\underset{-}{E_{Th}}} = 11.487\ \text{V} - 12.636\ \text{V} = \mathbf{-1.149\ V}$$

9. (I): R_{Th}:



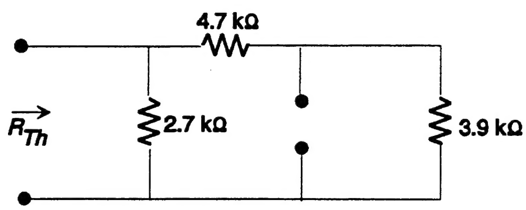
$$\leftarrow R_{Th} = 25\ \Omega + 60\ \Omega \| 30\ \Omega = 45\ \Omega$$

E_{Th}:



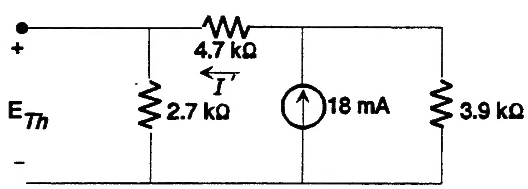
$$\begin{aligned} E_{Th} &= V_{30\Omega} - 10\ \text{V} - 0 \\ &= \frac{30\ \Omega(15\ \text{V})}{30\ \Omega + 60\ \Omega} - 10\ \text{V} \\ &= 5\ \text{V} - 10\ \text{V} \\ &= -5\ \text{V} \end{aligned}$$

(II): R_{Th}:



$$R_{Th} = 2.7\ \text{k}\Omega \parallel (4.7\ \text{k}\Omega + 3.9\ \text{k}\Omega) = 2.7\ \text{k}\Omega \parallel 8.6\ \text{k}\Omega = \mathbf{2.055\ k\Omega}$$

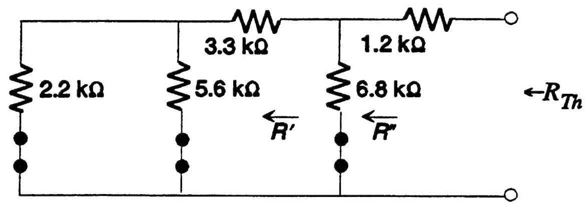
E_{Th}:



$$I' = \frac{3.9\ \text{k}\Omega(18\ \text{mA})}{3.9\ \text{k}\Omega + 7.4\ \text{k}\Omega} = 6.212\ \text{mA}$$

$$E_{Th} = I'(2.7\ \text{k}\Omega) = (6.212\ \text{mA})(2.7\ \text{k}\Omega) = \mathbf{16.772\ V}$$

11. R_{Th}:



$2.2\ \text{k}\Omega \parallel 5.6\ \text{k}\Omega = 1.579\ \text{k}\Omega$
$R' = 1.579\ \text{k}\Omega + 3.3\ \text{k}\Omega$
$= 4.879\ \text{k}\Omega$

$R'' = 4.879\ \text{k}\Omega \parallel 6.8\ \text{k}\Omega = 2.841\ \text{k}\Omega$
$R_{Th} = 1.2\ \text{k}\Omega + R'' = 1.2\ \text{k}\Omega + 2.841\ \text{k}\Omega = \mathbf{4.041\ k\Omega}$

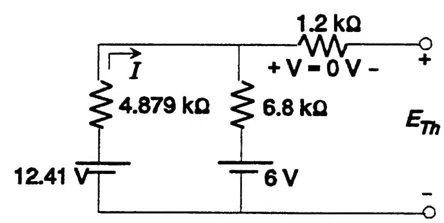
E_{Th}: Source conversions:

$$I_1 = \frac{22\ \text{V}}{2.2\ \text{k}\Omega} = 10\ \text{mA},\ R_s = 2.2\ \text{k}\Omega$$
$$I_2 = \frac{12\ \text{V}}{5.6\ \text{k}\Omega} = 2.143\ \text{mA},\ R_s = 5.6\ \text{k}\Omega$$

Combining parallel current sources: $I'_T = I_1 - I_2 = 10\ \text{mA} - 2.143\ \text{mA} = 7.857\ \text{mA}$

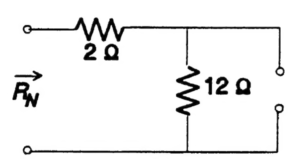
$2.2\ \text{k}\Omega \parallel 5.6\ \text{k}\Omega = 1.579\ \text{k}\Omega$

Source conversion:
$E = (7.857\ \text{mA})(1.579\ \text{k}\Omega) = 12.41\ \text{V}$
$R' = R_s + 3.3\ \text{k}\Omega = 1.579\ \text{k}\Omega + 3.3\ \text{k}\Omega = 4.879\ \text{k}\Omega$



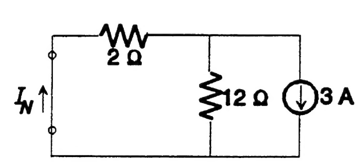
$$I = \frac{12.41\ \text{V} - 6\ \text{V}}{4.879\ \text{k}\Omega + 6.8\ \text{k}\Omega} = \frac{6.41\ \text{V}}{11.679\ \text{k}\Omega} = 0.549\ \text{mA}$$
$$V_{6.8\text{k}\Omega} = I(6.8\ \text{k}\Omega) = (0.549\ \text{mA})(6.8\ \text{k}\Omega) = 3.733\ \text{V}$$
$$E_{Th} = 6\ \text{V} + V_{6.8\text{k}\Omega} = 6\ \text{V} + 3.733\ \text{V} = \mathbf{9.733\ V}$$

13. (I) R_N:



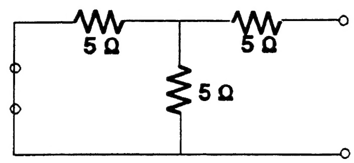
$R_N = 2\ \Omega + 12\ \Omega = \mathbf{14\ \Omega}$

I_N:



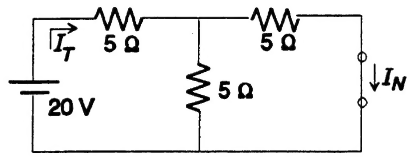
$$I_N = \frac{12\ \Omega(3\ \text{A})}{12\ \Omega + 2\ \Omega} = \mathbf{2.571\ A}$$

(II) R_N:



$$\leftarrow R_N = 5\ \Omega + \frac{5\ \Omega}{2} = \mathbf{7.5\ \Omega}$$

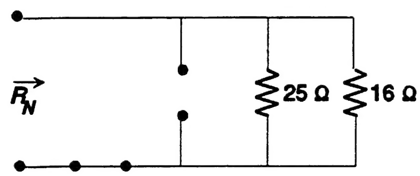
I_N:



$$I_T = \frac{20\ V}{5\ \Omega + \dfrac{5\ \Omega}{2}} = 2.667\ \text{A}$$

$$I_N = \frac{I_T}{2} = \mathbf{1.333\ A}$$

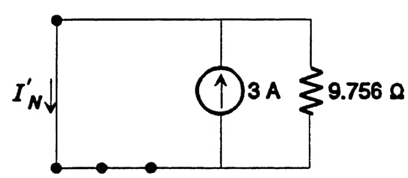
15. (a)



$$R_N = 25\ \Omega \parallel 16\ \Omega = \mathbf{9.756\ \Omega}$$

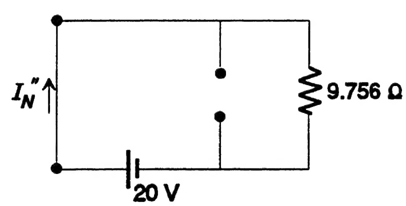
I_N: Superposition:

I:



$$I'_N = 3\ \text{A}$$

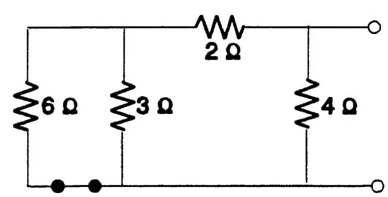
E:



$$I''_N = \frac{20\ \text{V}}{9.756\ \Omega} = 2.05\ \text{A}$$

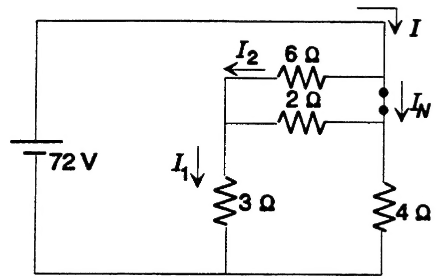
$I_N = I'_N - I''_N = 3\ \text{A} - 2.05\ \text{A} = \mathbf{0.95\ A}$ (direction of I'_N)

(b) R_N:



$$\leftarrow R_N = 4\ \Omega \parallel (2\ \Omega + 2\ \Omega) = \mathbf{2\ \Omega}$$

I_N:



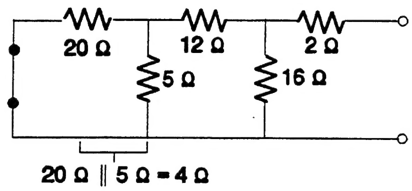
$$I = \frac{72\text{ V}}{4\ \Omega \| (3\ \Omega + 6\ \Omega \| 2\ \Omega)} = \frac{72\text{ V}}{2.118\ \Omega} \cong 34\text{ A}$$

$$I_1 = \frac{4\ \Omega(I)}{4\ \Omega + 4.5\ \Omega} = 16\text{ A}$$

$$I_2 = \frac{2\ \Omega(I_1)}{2\ \Omega + 6\ \Omega} = 4\text{ A}$$

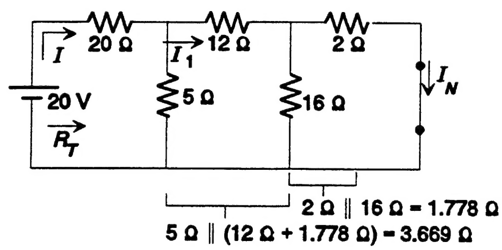
$$I_N = I - I_2 = 34\text{ A} - 4\text{ A} = \mathbf{30\text{ A}}$$

17. (a) R_N:



$$\leftarrow R_N = 2\ \Omega + 16\ \Omega \| (12\ \Omega + 4\ \Omega) = 2\ \Omega + 16\ \Omega \| 16\ \Omega = 2\ \Omega + 8\ \Omega = 10\ \Omega$$

I_N:

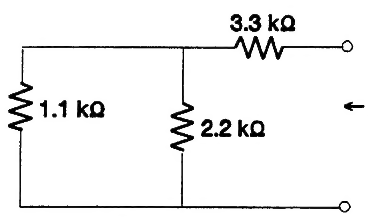


$$I = \frac{E}{R_T} = \frac{20\text{ V}}{20\ \Omega + 3.669\ \Omega} = 0.845\text{ A}$$

$$I_1 = \frac{5\ \Omega(0.845\text{ A})}{5\ \Omega + 13.778\ \Omega} = 0.225\text{ A}$$

$$I_N = \frac{16\ \Omega(0.225\text{ A})}{16\ \Omega + 2\ \Omega} = \mathbf{0.2\text{ A}}$$

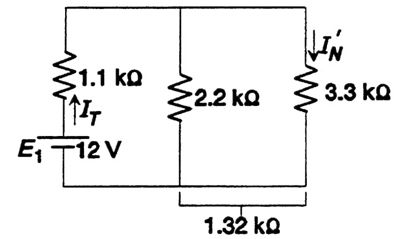
(b) R_N:



$$\leftarrow R_N = 3.3\text{ k}\Omega + 1.1\text{ k}\Omega \| 2.2\text{ k}\Omega = 3.3\text{ k}\Omega + 0.733\text{ k}\Omega = \mathbf{4.033\text{ k}\Omega}$$

I_N: **Superposition:**

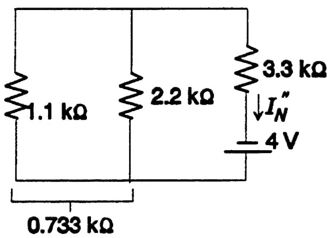
E_1:



$$I_T = \frac{12\text{ V}}{1.1\text{ k}\Omega + 1.32\text{ k}\Omega} = 4.959\text{ mA}$$

$$I'_N = \frac{2.2\text{ k}\Omega(4.959\text{ mA})}{2.2\text{ k}\Omega + 3.3\text{ k}\Omega} = 1.984\text{ mA}$$

E_2:



$$I''_N = \frac{4\text{ V}}{3.3\text{ k}\Omega + 0.733\text{ k}\Omega} = 0.9918\text{ mA}$$

$I_N = I'_N + I''_N = 1.984\text{ mA} + 0.9918\text{ mA} = \mathbf{2.9758\text{ mA}}$

19. a. (I) $R = R_{Th} = \mathbf{14\ \Omega}$
(II) $R = R_{Th} = \mathbf{7.5\ \Omega}$

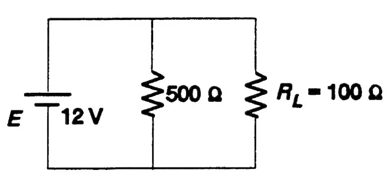
b. (I) $P_{max} = E_{Th}^2/4R_{Th} = (36\text{ V})^2/4(14\ \Omega) = \mathbf{23.14\text{ W}}$
(II) $P_{max} = E_{Th}^2/4R_{Th} = (10\text{ V})^2/4(7.5\ \Omega) = \mathbf{3.33\text{ W}}$

21. a. $R = R_{Th} = \mathbf{9.756\ \Omega}$
b. $R = R_{Th} = \mathbf{2\ \Omega}$

a. $P_{max} = E_{Th}^2/4R_{Th} = (9.268\text{ V})^2/4(9.756\ \Omega) = \mathbf{2.20\text{ W}}$
b. $P_{max} = E_{Th}^2/4R_{Th} = (60\text{ V})^2/4(2\ \Omega) = \mathbf{450\text{ W}}$

23. $P_{max} = \left[\dfrac{E_{Th}}{R_{Th} + R_4}\right]^2 R_4$
with $R_1 = \mathbf{0\ \Omega}$ $\quad E_{Th}$ is a maximum and R_{Th} a minimum
$\therefore$ P_{max} **a maximum**

25.



Since R_L fixed, maximum power to R_L when V_{R_L} a maximum as defined by $P_L = \dfrac{V_{R_L}^2}{R_L}$

$\therefore$ $R = \mathbf{500\ \Omega}$ and $P_{max} = \dfrac{(12\text{V})^2}{100\ \Omega} = 1.44\text{ W}$

27. $E_{eq} = \dfrac{-5 \text{ V}/2.2 \text{ k}\Omega + 20 \text{ V}/8.2 \text{ k}\Omega}{1/2.2 \text{ k}\Omega + 1/8.2 \text{ k}\Omega} = 0.2879 \text{ V}$

$R_{eq} = \dfrac{1}{1/2.2 \text{ k}\Omega + 1/8.2 \text{ k}\Omega} = 1.7346 \text{ k}\Omega$

$I_L = \dfrac{E_{eq}}{R_{eq} + R_L} = \dfrac{0.2879 \text{ V}}{1.7346 \text{ k}\Omega + 5.6 \text{ k}\Omega} = \mathbf{39.3\ \mu A}$

$V_L = I_L R_L = (39.3\ \mu\text{A})(5.6 \text{ k}\Omega) = \mathbf{220\ mV}$

29. $I_{eq} = \dfrac{(4 \text{ A})(4.7\ \Omega) + (1.6 \text{ A})(3.3\ \Omega)}{4.7\ \Omega + 3.3\ \Omega} = \dfrac{18.8 \text{ V} + 5.28 \text{ V}}{8\ \Omega} = 3.01 \text{ A}$

$R_{eq} = 4.7\ \Omega + 3.3\ \Omega = 8\ \Omega$

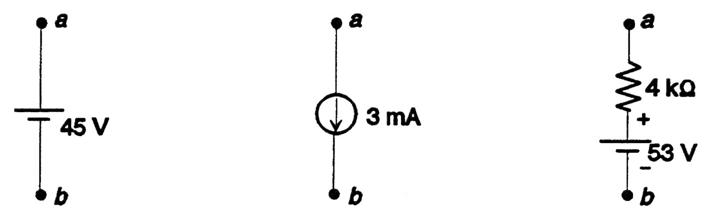
$I_L = \dfrac{R_{eq}(I_{eq})}{R_{eq} + R_L} = \dfrac{8\ \Omega(3.01 \text{ A})}{8\ \Omega + 2.7\ \Omega} = \mathbf{2.25\ A}$

$V_L = I_L R_L = (2.25 \text{ A})(2.7\ \Omega) = \mathbf{6.075\ V}$

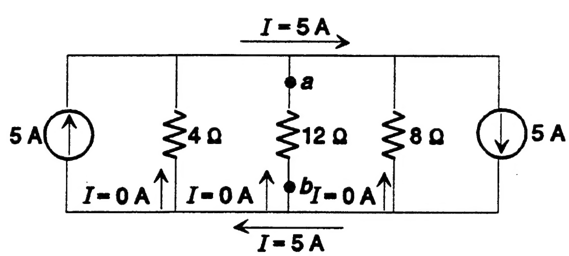
31. $15 \text{ k}\Omega \parallel (8 \text{ k}\Omega + 7 \text{ k}\Omega) = 15 \text{ k}\Omega \parallel 15 \text{ k}\Omega = 7.5 \text{ k}\Omega$

$V_{ab} = \dfrac{7.5\text{k}\Omega(60 \text{ V})}{7.5 \text{ k}\Omega + 2.5 \text{ k}\Omega} = 45 \text{ V}$

$I_{ab} = \dfrac{45 \text{ V}}{15 \text{ k}\Omega} = 3 \text{ mA}$



33.

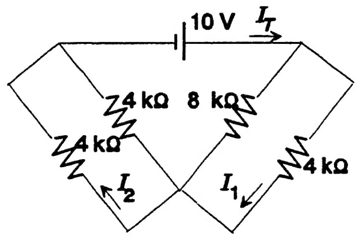


$V_{ab} = 0$ V (short)
$I_{ab} = 0$ A (open)

R_2 any resistive value

$\therefore R_2$ = short-circuit, open-circuit, any value

35. (a)

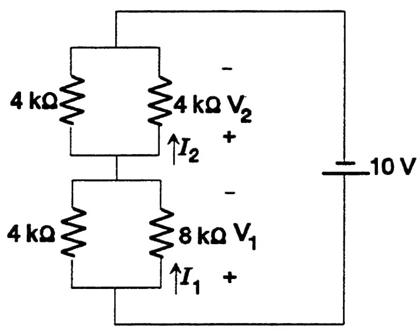


$$I_T = \frac{10\text{ V}}{4\text{ k}\Omega \| 8\text{ k}\Omega + 4\text{ k}\Omega \| 4\text{ k}\Omega} = \frac{10\text{ V}}{2.667\text{ k}\Omega + 2\text{ k}\Omega} = \frac{10\text{ V}}{4.667\text{ k}\Omega} = 2.143\text{ mA}$$

$$I_1 = \frac{8\ \Omega(I_T)}{8\ \Omega + 4\ \Omega} = 1.429\text{ mA},\ I_2 = I_T/2 = 1.0715\text{ mA}$$

$$I = I_1 - I_2 = 1.429\text{ mA} - 1.0715\text{ mA} = \mathbf{0.357\ mA}$$

(b)



$$V_1 = \frac{(8\text{ k}\Omega \| 4\text{ k}\Omega)(10\text{ V})}{8\text{ k}\Omega \| 4\text{ k}\Omega + 4\text{ k}\Omega \| 4\text{ k}\Omega} = 5.715\text{ V}$$

$$I_1 = \frac{V_1}{8\text{ k}\Omega} = 0.714\text{ mA}$$

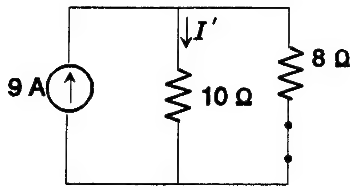
$$V_2 = E - V_1 = 10\text{ V} - 5.715\text{ V} = 4.285\text{ V}$$

$$I_2 = \frac{V_2}{4\text{ k}\Omega} = 1.071\text{ mA}$$

$$I = I_2 - I_1 = 1.071\text{ mA} - 0.714\text{ mA} = \mathbf{0.357\ mA}$$

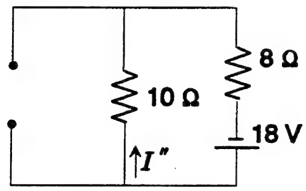
CHAPTER 9 (Even)

2. a. I:



$$I' = \frac{8\ \Omega(9\ \text{A})}{8\ \Omega + 10\ \Omega} = 4\ \text{A}$$

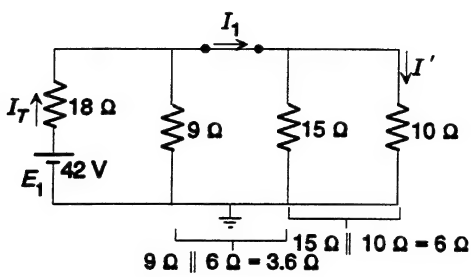
E:



$$I'' = \frac{18\ \text{V}}{10\ \Omega + 8\ \Omega} = 1\ \text{A}$$

$I(\text{dir. of } I') = I' - I'' = 4\ \text{A} - 1\ \text{A} = \mathbf{3\ A}$

b. E_1:

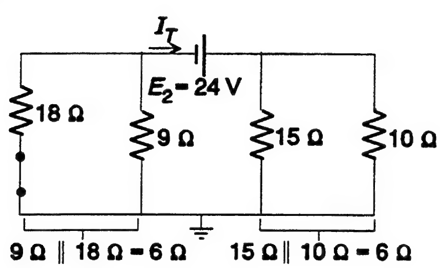


$$I_T = \frac{42\ \text{V}}{18\ \Omega + 3.6\ \Omega} = 1.944\ \text{A}$$

$$I_1 = \frac{9\ \Omega(I_T)}{9\ \Omega + 6\ \Omega} = \frac{9\ \Omega(1.944\ \text{A})}{15\ \Omega} = 1.1664\ \text{A}$$

$$I' = \frac{15\ \Omega(I_1)}{15\ \Omega + 10\ \Omega} = \frac{15\ \Omega(1.1664\ \text{A})}{25\ \Omega} = 0.7\ \text{A}$$

E_2:

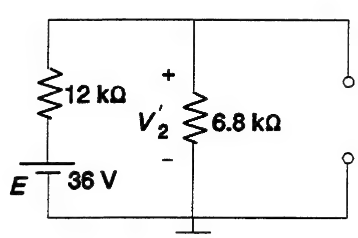


$$I_T = \frac{E_2}{R_T} = \frac{24\ \text{V}}{12\ \Omega} = 2\ \text{A}$$

$$I'' = \frac{15\ \Omega(I_T)}{15\ \Omega + 10\ \Omega} = 1.2\ \text{A}$$

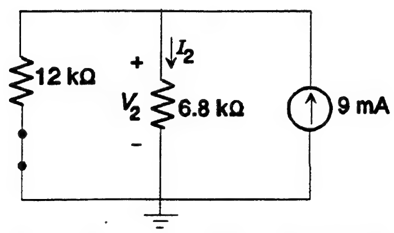
$I_{10\Omega} = I' + I'' = 0.7\ \text{A} + 1.2\ \text{A} = \mathbf{1.9\ A}$

4. E:



$$V'_2 = \frac{6.8\ \text{k}\Omega(36\ \text{V})}{6.8\ \text{k}\Omega + 12\ \text{k}\Omega} = 13.02\ \text{V}$$

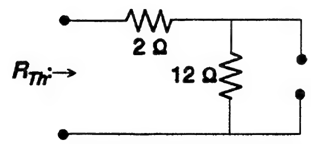
I:



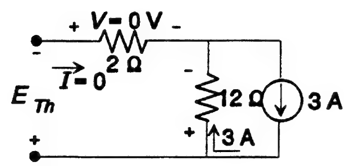
$$I_2 = \frac{12\ \text{k}\Omega(9\ \text{mA})}{12\ \text{k}\Omega + 6.8\ \text{k}\Omega} = 5.745\ \text{mA}$$

$V''_2 = I_2R_2 = (5.745\ \text{mA})(6.8\ \text{k}\Omega) = 39.06\ \text{V}$
$V_2 = V'_2 + V''_2 = 13.02\ \text{V} + 39.06\ \text{V} = \mathbf{52.08\ V}$

6. (I) a.



$R_{Th} = 2\ \Omega + 12\ \Omega = 14\ \Omega$

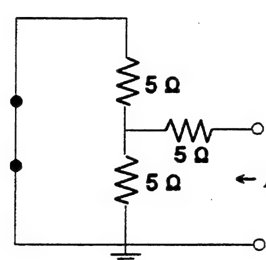


$E_{Th} = IR = (3\ \text{A})(12\ \Omega) = 36\ \text{V}$

b. $R = 2\ \Omega$: $P = \left[\dfrac{E_{Th}}{R_{Th} + R}\right]^2 R = \left[\dfrac{36\ \text{V}}{14\ \Omega + 2\ \Omega}\right]^2 2\ \Omega = \mathbf{10.125\ W}$

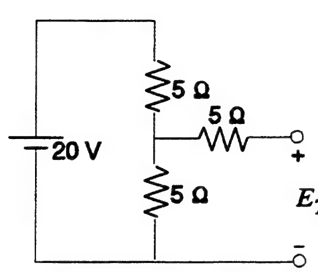
$R = 100\ \Omega$: $P = \left[\dfrac{36\ \text{V}}{14\ \Omega + 100\ \Omega}\right]^2 100\ \Omega = \mathbf{9.9723\ W}$

(II) a. R_{Th}:



$\leftarrow R_{Th} = 5\ \Omega + 5\ \Omega \parallel 5\ \Omega = \mathbf{7.5\ \Omega}$

E_{Th}:

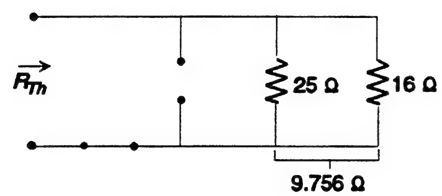


$E_{Th} = \dfrac{20\ \text{V}}{2} = \mathbf{10\ V}$

b. $R = 2\ \Omega$: $P = \left[\dfrac{E_{Th}}{R_{Th} + R}\right]^2 R = \left[\dfrac{10\ \text{V}}{7.5\ \Omega + 2\ \Omega}\right]^2 2\ \Omega = \mathbf{2.2161\ W}$

$R = 100\ \Omega$: $P = \left[\dfrac{10\ \text{V}}{7.5\ \Omega + 100\ \Omega}\right]^2 100\ \Omega = \mathbf{0.8653\ W}$

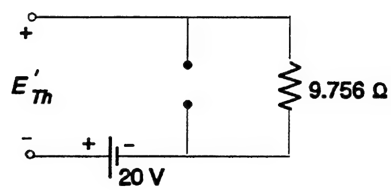
8. a. R_{Th}:



$R_{Th} = 25\ \Omega \parallel 16\ \Omega = \mathbf{9.756\ \Omega}$

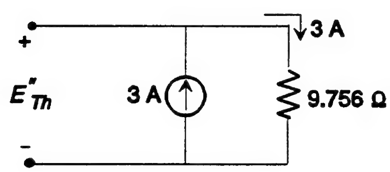
E_{Th}: Superposition:

E:



$E'_{Th} = -20\ \text{V}$

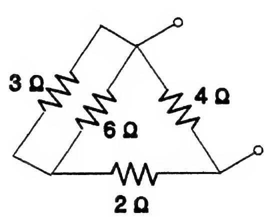
I:



$E''_{Th} = (3\ \text{A})(9.756\ \Omega) = 29.268\ \text{V}$

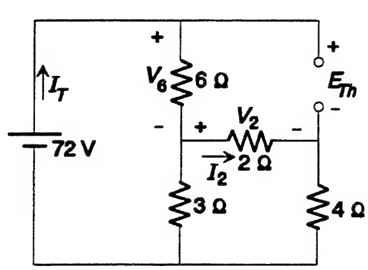
$E_{Th} = E''_{Th} - E'_{Th} = 29.268\ \text{V} - 20\ \text{V} = \mathbf{9.268\ V}$

b. R_{Th}:



$R_{Th} = 4\ \Omega \parallel (2\ \Omega + 6\ \Omega \parallel 3\ \Omega) = 2\ \Omega$

E_{Th}:

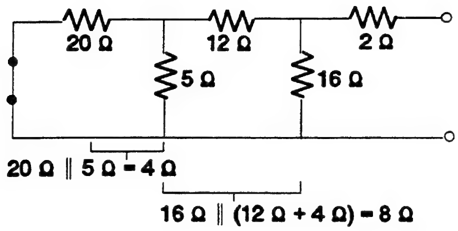


$$I_T = \frac{72\ \text{V}}{6\ \Omega + 3\ \Omega \parallel (2\ \Omega + 4\ \Omega)} = 9\ \text{A}$$

$$I_2 = \frac{3\ \Omega(I_T)}{3\ \Omega + 6\ \Omega} = \frac{3\ \Omega(9\ \text{A})}{9\ \Omega} = 3\ \text{A}$$

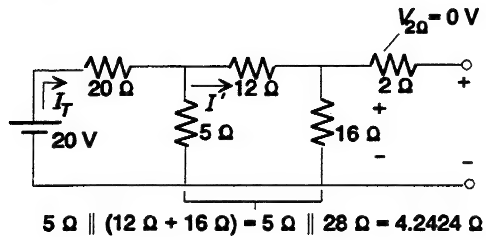
$$E_{Th} = V_6 + V_2 = (I_T)(6\ \Omega) + I_2(2\ \Omega)$$
$$= (9\text{A})(6\ \Omega) + (3\ \text{A})(2\ \Omega) = \mathbf{60\ V}$$

10. a. R_{Th}:



$\leftarrow R_{Th} = 2\ \Omega + 8\ \Omega = \mathbf{10\ \Omega}$

E_{Th}:



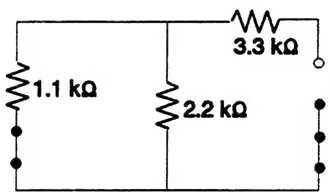
$E_{Th} = V_{16\Omega}$

$$I_T = \frac{20\text{ V}}{20\ \Omega + 4.2424\ \Omega} = 0.825\text{ A}$$

$$I' = \frac{5\ \Omega(I_T)}{5\ \Omega + 28\ \Omega} = \frac{5\ \Omega(0.825\text{ A})}{33\ \Omega} = 0.125\text{ A}$$

$$E_{Th} = V_{16\Omega} = (I')(16\ \Omega) = (0.125\text{ A})(16\ \Omega) = \mathbf{2\ V}$$

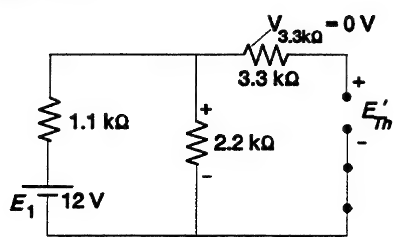
b. R_{Th}:



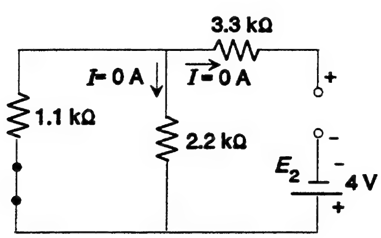
$$\leftarrow R_{Th} = 3.3\text{ k}\Omega + 2.2\text{ k}\Omega \parallel 1.1\text{ k}\Omega$$
$$= 3.3\text{ k}\Omega + 0.733\text{ k}\Omega$$
$$= \mathbf{4.033\ k\Omega}$$

E_{Th}: Superposition:

E_1:



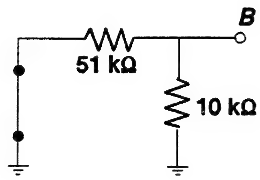
$$E'_{Th} = V_{2.2k\Omega} = \frac{2.2\text{ k}\Omega(12\text{ V})}{2.2\text{ k}\Omega + 1.1\text{ k}\Omega}$$
$$= 8\text{ V}$$



$E_{Th}'' = E_2 = 4\text{ V}$

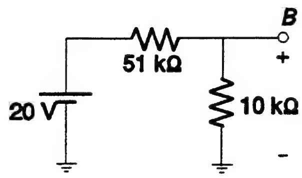
$$E_{Th} = E'_{Th} + E''_{Th} = 8\text{ V} + 4\text{ V} = \mathbf{12\ V}$$

12. a. R_{Th}:



$\leftarrow R_{Th} = 51\text{ k}\Omega \parallel 10\text{ k}\Omega = \mathbf{8.36\text{ k}\Omega}$

E_{Th}:



$$E_{Th} = \frac{10\text{ k}\Omega(20\text{ V})}{10\text{ k}\Omega + 51\text{ k}\Omega} = \mathbf{3.28\text{ V}}$$

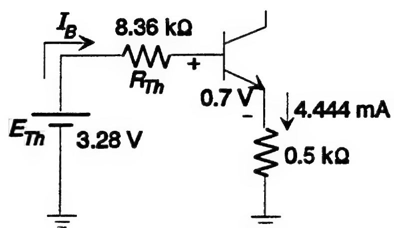
b. $I_E R_E + V_{CE} + I_C R_C = 20\text{ V}$

but $I_C \cong I_E$

and $I_E(R_C + R_E) + V_{CE} = 20\text{ V}$

$$\text{or } I_E = \frac{20\text{ V} - V_{CE}}{R_C + R_E} = \frac{20\text{ V} - 8\text{ V}}{2.2\text{ k}\Omega + 0.5\text{ k}\Omega} = \frac{12\text{ V}}{2.7\text{ k}\Omega} = \mathbf{4.444\text{ mA}}$$

c.



$$E_{Th} - I_B R_{Th} - V_{BE} - V_E = 0$$

$$\text{and } I_B = \frac{E_{Th} - V_{BE} - V_E}{R_{Th}} = \frac{3.28\text{ V} - 0.7\text{ V} - (4.444\text{ mA})(0.5\text{ k}\Omega)}{8.36\text{ k}\Omega}$$

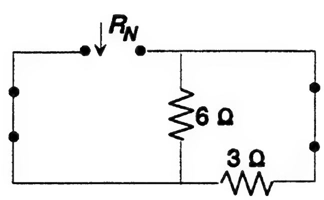
$$= \frac{2.58\text{ V} - 2.222\text{ V}}{8.36\text{ k}\Omega} = \frac{0.358\text{ V}}{8.36\text{ k}\Omega} = \mathbf{42.82\ \mu A}$$

d. $V_C = 20\text{ V} - I_C R_C = 20\text{ V} - (4.444\text{ mA})(2.2\text{ k}\Omega)$

$= 20\text{ V} - 9.777\text{ V}$

$= \mathbf{10.223\text{ V}}$

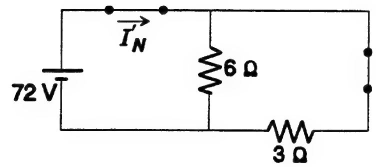
14. (I)(a) R_N:



$R_N = 6\ \Omega \parallel 3\ \Omega = \mathbf{2\ \Omega}$

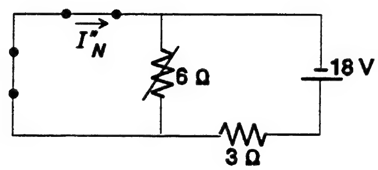
I_N:

E_1:



$$I'_N = \frac{72\ \text{V}}{6\ \Omega \parallel 3\ \Omega} = 36\ \text{A}$$

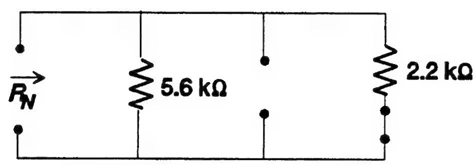
E_2:



$$I''_N = \frac{18\ \text{V}}{3\ \Omega} = 6\ \text{A}$$

$$I_N = I'_N + I''_N = 36\ \text{A} + 6\ \text{A} = \mathbf{42\ A}$$

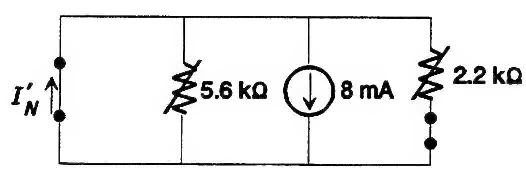
(II)(a) R_N:



$$R_N = 5.6\ \text{k}\Omega \parallel 2.2\ \text{k}\Omega = \mathbf{1.5795\ k\Omega}$$

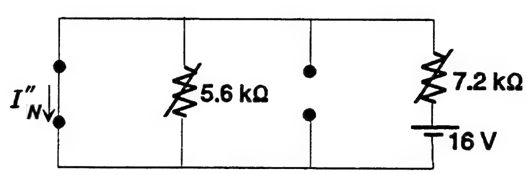
I_N:

I:



$$I'_N = 8\ \text{mA}$$

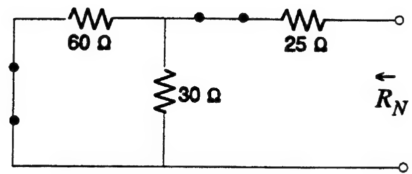
E:



$$I''_N = \frac{16\ \text{V}}{2.2\ \text{k}\Omega} = 7.2727\ \text{mA}$$

$$I_N\uparrow = 8\ \text{mA} - 7.2727\ \text{mA} = \mathbf{0.7273\ mA}$$

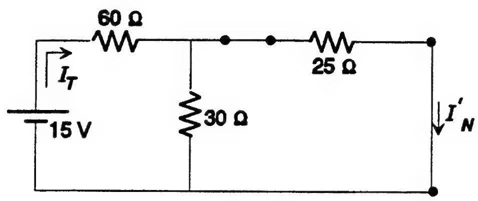
16. (I)(a) R_N:



$$\overleftarrow{R_N} = 25\ \Omega + 60\ \Omega \parallel 30\ \Omega = 25\ \Omega + 20\ \Omega = 45\ \Omega$$

I_N:

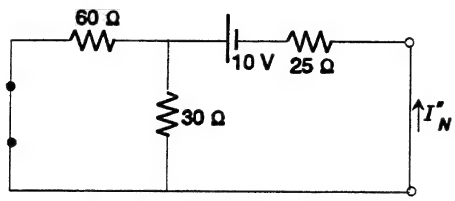
$E = 15$ V:



$$I_T = \frac{15\ \text{V}}{60\ \Omega + 30\ \Omega \parallel 25\ \Omega} = 0.2037\ \text{A}$$

$$I'_N = \frac{30\ \Omega(I_T)}{30\ \Omega + 25\ \Omega} = 0.1111\ \text{A}$$

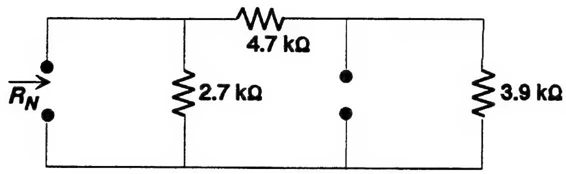
$E = 10$ V:



$$I''_N = \frac{10\ \text{V}}{25\ \Omega + 60\ \Omega \parallel 30\ \Omega} = \frac{10\ \text{V}}{25\ \Omega + 20\ \Omega} = 0.2222\ \text{A}$$

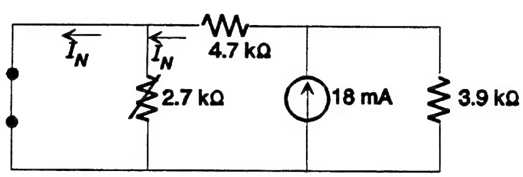
I_N (dir of I''_N) $= I''_N - I'_N = 0.2222\ \text{A} - 0.1111\ \text{A} =$ **0.111 A**

(II)(a) R_N:



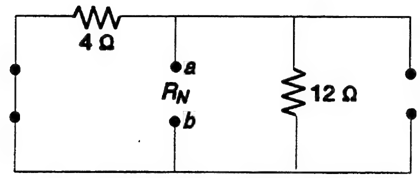
$$R_N = 2.7\ \text{k}\Omega \parallel (4.7\ \text{k}\Omega + 3.9\ \text{k}\Omega) = \mathbf{2.055\ k\Omega}$$

I_N:



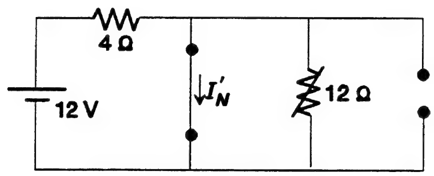
$$I_N = \frac{3.9\ \text{k}\Omega(18\ \text{mA})}{3.9\ \text{k}\Omega + 4.7\ \text{k}\Omega} = \mathbf{8.163\ mA}$$

18. a. R_N:



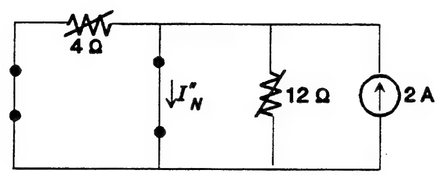
$R_N = 4\ \Omega \parallel 12\ \Omega = \mathbf{3\ \Omega}$

$E = 12$ V:



$$I'_N = \frac{12\text{ V}}{4\ \Omega} = 3\text{ A}$$

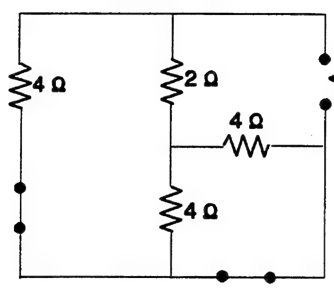
$I = 2$ A:



$I''_N = 2$ A

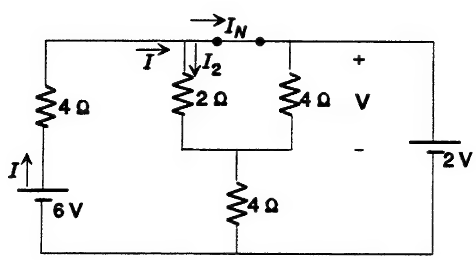
$$I_N = I'_N + I''_N = 3\text{ A} + 2\text{ A} = \mathbf{5\ A}$$

b. R_N:



$$\leftarrow R_N = (2\ \Omega + 4\ \Omega \parallel 4\ \Omega) \parallel 4\ \Omega$$
$$= (2\ \Omega + 2\ \Omega) \parallel 4\ \Omega$$
$$= \frac{4\ \Omega}{2} = \mathbf{2\ \Omega}$$

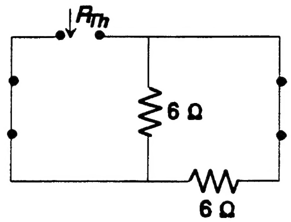
I_N:



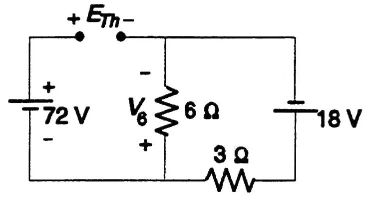
$$I = \frac{V_{4\Omega}}{4\ \Omega} = \frac{6\text{ V} - 2\text{ V}}{4\ \Omega} = \frac{4\text{ V}}{4\ \Omega}$$
$$= 1\text{ A}$$
$$V = \frac{(4\ \Omega \parallel 2\ \Omega)(2\text{ V})}{(4\ \Omega \parallel 2\ \Omega) + 4\ \Omega}$$
$$= 0.5\text{ V}$$
$$I_2 = \frac{V}{R} = \frac{0.5\text{ V}}{2\ \Omega} = 0.25\text{ A}$$

$$I_N = I - I_2 = 1\text{ A} - 0.25\text{ A} = \mathbf{0.75\ A}$$

20. (I) a.



$R_{Th} = R = 6\ \Omega \parallel 3\ \Omega = \mathbf{2\ \Omega}$

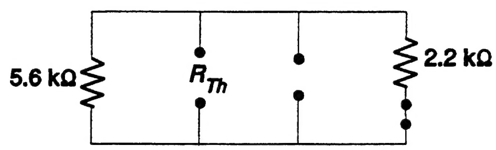


$$V_6 = \frac{6\ \Omega(18\ \text{V})}{6\ \Omega + 3\ \Omega} = 12\ \text{V}$$

$$E_{Th} = 72\ \text{V} + V_6$$
$$= 72\ \text{V} + 12\ \text{V} = \mathbf{84\ V}$$

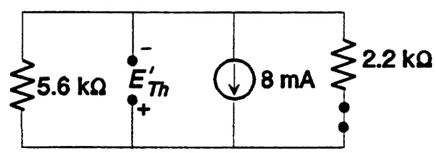
b. $P_{max} = \dfrac{E_{Th}^2}{4R_{Th}} = \dfrac{(84\ \text{V})^2}{4(2\ \Omega)} = \mathbf{882\ W}$

(II) a. R_{Th}:

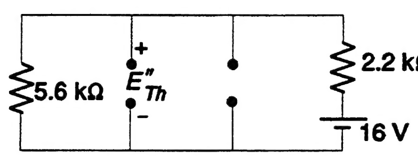


$R_{Th} = 5.6\ \text{k}\Omega \parallel 2.2\ \text{k}\Omega$
$= \mathbf{1.5795\ k\Omega}$

b. E_{Th}:



$E'_{Th} = 8\ \text{mA}(2.2\ \text{k}\Omega \parallel 5.6\ \text{k}\Omega)$
$= 8\ \text{mA}(1.5795\ \text{k}\Omega)$
$= 12.636\ \text{V}$

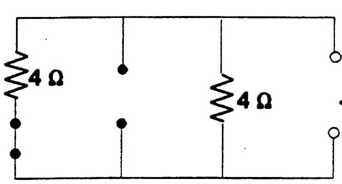


$$E''_{Th} = \frac{5.6\ \text{k}\Omega(16\ \text{V})}{5.6\ \text{k}\Omega + 2.2\ \text{k}\Omega}$$
$$= 11.487\ \text{V}$$

E_{Th} (polarity of E'_{Th}) $= E'_{Th} - E''_{Th}$
$= 12.636\ \text{V} - 11.487\ \text{V} = \mathbf{1.149\ V}$

$$P_{max} = \frac{E_{Th}^2}{4R_{Th}} = \frac{(1.149\ \text{V})^2}{4(1.5795\ \text{k}\Omega)} = \mathbf{0.21\ mW}$$

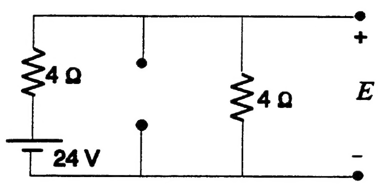
22. a.



$\leftarrow R = R_{Th} = 4\ \Omega \parallel 4\ \Omega = \mathbf{2\ \Omega}$

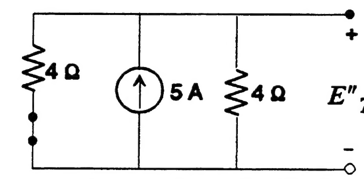
b. E_{Th}:

E:



$$E'_{Th} = \frac{24\ \text{V}}{2} = 12\ \text{V}$$

I:

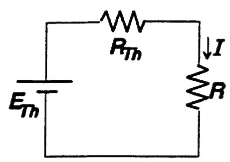


$$E''_{Th} = IR_T = (5\ \text{A})(4\ \Omega \parallel 4\ \Omega)$$
$$= (5\ \text{A})(2\ \Omega)$$
$$= 10\ \text{V}$$

$$E_{Th} = E'_{Th} + E''_{Th} = 12\ \text{V} + 10\ \text{V} = \mathbf{22\ V}$$

$$P_{max} = \frac{E^2_{Th}}{4R_{Th}} = \frac{(22\ \text{V})^2}{4(2\ \Omega)} = \mathbf{60.5\ W}$$

c.



$$P = I^2R = \left[\frac{E_{Th}}{R_{Th} + R}\right]^2 R$$

$R = \frac{1}{4}(2\ \Omega) = 0.5\ \Omega$, $P = \mathbf{38.72\ W}$

$R = \frac{1}{2}(2\ \Omega) = 1\ \Omega$, $P = \mathbf{53.78\ W}$

$R = \frac{3}{4}(2\ \Omega) = 1.5\ \Omega$, $P = \mathbf{59.27\ W}$

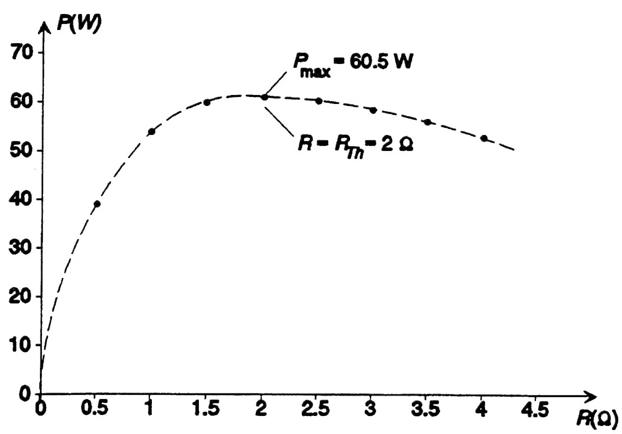
$\mathbf{R = 2\ \Omega}$, $\mathbf{P = 60.5\ W}$

$R = \frac{5}{4}(2\ \Omega) = 2.5\ \Omega$, $P = \mathbf{59.75\ W}$

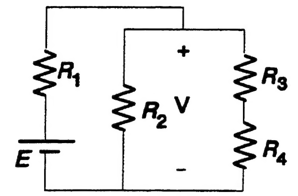
$R = \frac{3}{2}(2\ \Omega) = 3\ \Omega$, $P = \mathbf{58\ W}$

$R = \frac{7}{4}(2\ \Omega) = 3.5\ \Omega$, $P = \mathbf{56\ W}$

$R = 2(2\ \Omega) = 4\ \Omega$, $P = \mathbf{53.78\ W}$



24. a.

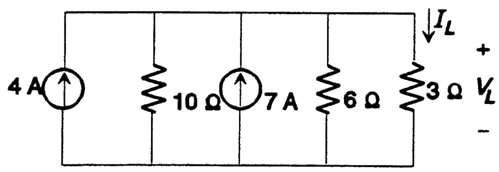


V, and therefore V_4, will be its largest value when R_2 is as large as possible. Therefore choose R_2 = open-circuit ($\infty\ \Omega$).

Then $P_4 = \dfrac{V_4^2}{R_4}$ will be a maximum.

b. No, examine each individually.

26.



$I_T\uparrow = 4\text{ A} + 7\text{ A} = 11\text{ A}$

$R_T = 10\ \Omega \parallel 6\ \Omega \parallel 3\ \Omega = 1.667\ \Omega$

$V_L = I_T R_T = (11\text{ A})(1.667\ \Omega) = \mathbf{18.34\ V}$

$$I_L = \frac{V_L}{R_L} = \frac{18.34\text{ V}}{3\ \Omega} = \mathbf{6.113\ A}$$

28. $I_T\downarrow = 2\text{ A} - 0.2\text{ A} - 0.001\text{ A} = 1.799\text{ A}$

$R_T = 200\ \Omega \parallel 200\ \Omega \parallel 100\ \Omega \parallel 10\text{ k}\Omega = 49.751\ \Omega$

$V_L = I_T R_T = (1.799\text{ A})(49.751\ \Omega) = 89.5\text{ V}$

$$I_L = \frac{V_L}{R_L} = \frac{89.5\text{ V}}{200\ \Omega} = \mathbf{0.448\ A}$$

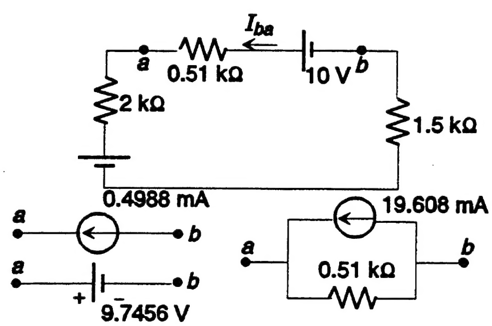
30.
$$\overleftarrow{I_{eq}} = \frac{(4\text{ mA})(8.2\text{ k}\Omega) + (8\text{ mA})(4.7\text{ k}\Omega) - (10\text{ mA})(2\text{ k}\Omega)}{8.2\text{ k}\Omega + 4.7\text{ k}\Omega + 2\text{ k}\Omega}$$
$$= \frac{32.8\text{ V} + 37.6\text{ V} - 20\text{ V}}{14.9\text{ k}\Omega} = 3.3826\text{ mA}$$

$R_{eq} = 8.2\text{ k}\Omega + 4.7\text{ k}\Omega + 2\text{ k}\Omega = 14.9\text{ k}\Omega$

$$I_L = \frac{R_{eq}I_{eq}}{R_{eq} + R_L} = \frac{(14.9\text{ k}\Omega)(3.3826\text{ mA})}{14.9\text{ k}\Omega + 6.8\text{ k}\Omega} = \mathbf{2.3226\ mA}$$

$V_L = I_L R_L = (2.3226\text{ mA})(6.8\text{ k}\Omega) = \mathbf{15.7937\ V}$

32.



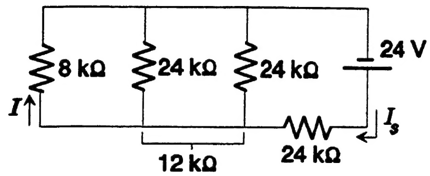
$$I_{ba} = \frac{10\text{ V} - 8\text{ V}}{2\text{ k}\Omega + 0.51\text{ k}\Omega + 1.5\text{ k}\Omega}$$
$= \mathbf{0.4988\ mA}$

$V_{0.51\text{k}\Omega} = (0.4988\text{ mA})(0.51\text{ k}\Omega)$
$= 0.2544\text{ V}$

$V_{ab} = 10\text{ V} - 0.2544\text{ V} = 9.7456\text{ V}$
+-

34. a.
$$I_s = \frac{24\text{ V}}{8\text{ k}\Omega + \dfrac{24\text{ k}\Omega}{3}} = 1.5\text{ mA},\ I = \frac{I_s}{3} = \mathbf{0.5\ mA}$$

b.



$$I_s = \frac{24\ \text{V}}{24\ \text{k}\Omega + 8\ \text{k}\Omega \| 12\ \text{k}\Omega} = 0.8333\ \text{mA}$$

$$I = \frac{12\ \text{k}\Omega(I_s)}{12\ \text{k}\Omega + 8\ \text{k}\Omega} = \mathbf{0.5\ mA}$$

c. yes

36. a. $I_{R_2} = \dfrac{R_1(I)}{R_1 + R_2 + R_3} = \dfrac{3\Omega(6\ \text{A})}{3\ \Omega + 2\ \Omega + 4\ \Omega} = 2\text{A}$

$V = I_{R_2}R_2 = (2\ \text{A})(2\ \Omega) = \mathbf{4\ V}$

b. $I_{R_1} = \dfrac{R_2(I)}{R_1 + R_2 + R_3} = \dfrac{2\ \Omega(6\ \text{A})}{3\ \Omega + 2\ \Omega + 4\ \Omega} = 1.333\ \text{A}$

$V = I_{R_1}R_1 = (1.333\ \text{A})(3\ \Omega) = \mathbf{4\ V}$

c. yes